

APPENDIX I - Lidar Instruments

Lidar spectroscopy is an analytical technique with a long history in environmental science and chemistry. This method has been used widely in atmospheric chemistry and has a heritage in ground-based as well as space-based instruments. The lidar technique needs no further justification as a primary technique for the NDACC; however, individual instruments must still be validated. This description is intended to apply to the determination of the vertical distribution of ozone, temperature, aerosols, and water vapor.

Quality Criteria for the Evaluation of New Instruments and Instrument Teams

Independent Evaluation of the Instrument Design and Data Analysis

The NDACC has accepted lidar measurement techniques as valid methods for measuring and monitoring stratospheric temperature, aerosols, and ozone, tropospheric ozone, and tropospheric and lower stratospheric water vapor. Prior to a formal intercomparison of the new instrument(s), the Investigator should supply the NDACC Lidar Working Group (LWG) with a detailed technical description of the instrument and its general operating parameters. In the case of water vapor measurement, the Investigator should supply the NDACC LWG with a detailed description of the calibration procedure, with special emphasis on its accuracy and long-term stability.

Instrument and Data Analysis Intercomparison

There are several ways lidar instruments within the NDACC can be validated (temperature, aerosols, ozone, water vapor):

- Blind intercomparison of lidar systems located at the same site for a given period of time may be conducted. Such validations can be made either through a validation exercise using an NDACC mobile lidar system, or by comparing a new instrument with an already established lidar system at a given NDACC site. Such intercomparisons should follow the rules of the NDACC Intercomparison Protocol.
- Intercomparisons on a statistical basis with a satellite-borne instrument measuring the same quantity as the lidar can also be performed (for example, solar occultation instruments for ozone and/or aerosols measurements). Such intercomparisons have to be made on the long term to remove much of the natural variability. In this respect, the satellite instrument is used as a traveling standard between the various lidar stations.
- Intercomparisons on a statistical long-term basis may occur with other lidar instruments located at other neighboring sites.
- Side-by-side intercomparison with other instruments measuring the same atmospheric variable on the same NDACC site also are recommended.
- Algorithm intercomparisons also can be performed using a common database established within the NDACC Lidar Instrument Group, which includes synthetic data derived from atmospheric and instrument models, raw data provided by validated lidar systems within the NDACC, and the ancillary data required for data inversion.
- For the measurement of water vapor, calibration methods should be optimized, validated and compared with the primary purpose of maintaining

the best possible accuracy and long-term stability. For each instrument, the use of multiple and/or time-overlapping calibration procedures is recommended.

It is mandatory within the NDACC that a given lidar system has at least undergone satellite and algorithm validations. A plan also should be established for a blind intercomparison validation within the first three years of operation.

Quality Criteria for the Evaluation of Continuing Instruments and Instrument Teams

The validation record of a given instrument will be evaluated on a two-year basis by the LWG. Lidar Investigators should provide the following information.

- A document describing the instrument and data acquisition procedures.
- A document describing the algorithm to be used, including the forward and retrieval models, the method of error analysis, and the ancillary data (spectroscopic data, atmospheric parameters) used for the inversion.
- The validation record of the instrument.
- For water vapor, a document describing the calibration history of the instrument.

In addition, NDACC lidar Instrument Investigators are required to participate in ongoing validation exercises such as algorithm intercomparisons and satellite data long-term analysis.

Changes in Instruments and Data Analysis

Since one of the major goals of the NDACC is the detection of long-term trends, care should be used with any modifications of the instrument or data analysis which may affect the results. Once the regular operation of an instrument has begun, such changes should not be undertaken lightly; consultation with the LWG is recommended. The primary data (raw signals) should be retained by the Investigator indefinitely (although not deposited in the NDACC archive), so that improved data-retrieval processes can be applied retrospectively to the earlier data. In such cases, the entire dataset should be reprocessed and archived, along with (at least) reference to earlier versions. For the measurement of water vapor, instrumental changes should be immediately preceded and immediately followed by intensive calibration evaluation campaigns. The change in the calibration parameter(s) resulting from instrumental changes should be clearly reported and documented when archiving the data.